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An integrated laparoscopic simulator (i-Sim™) to develop surgical skills outside the operating theatre: A novel means to improve training facilities in the UK

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ABSTRACT

Background: Minimal access surgery (MAS) is increasingly replacing open surgery. However, access to training in laparoscopy remains lacking. We propose the use of a novel and integrated laparoscopic simulator (i-Sim™) to develop surgical skills.
Objectives: This pilot study set out to evaluate access to laparoscopic training facilities in the UK. It was then examined whether i-Sim™ might be a better alternative to the mannequin/box trainer with stack system.
Methods: Questionnaires were sent to consultants and trainees in urology, general surgery and gynaecology to survey current access to laparoscopic training in the UK. A further group was requested to give feature scores for i-Sim™ compared to a conventional mannequin/box trainer with stack system.
Results: Of those with laparoscopic experience, 36% believed they had opportunities in laparoscopic training only during operations while 17% felt they had no access to training facilities for laparoscopy. Overall, 93% thought a laparoscopic simulator would be useful for training. In the second survey, feature (set-up, image quality, user-friendliness, ease to change tasks, portability, different locations, storage) scores were given; i-Sim™ scored a significantly higher ($p < 0.0001$) satisfaction rating than the mannequin/box trainer with stack system.
Conclusions: There is a paucity of regular training facilities for MAS in the UK and there was an exceptionally strong agreement among our participants that regular training on laparoscopic simulators would be useful. Additionally, i-Sim™ offers the possibility of a readily accessible alternative to current training approaches to laparoscopy.

1. Introduction

The last two decades have witnessed a rapid evolution and refinement in minimal access surgery (MAS) as an alternative to many traditional open procedures in general surgery, urology and gynaecology. As new laparoscopic procedures become the standard-of-care, there is expansion and ongoing development of both techniques and instruments. Unfortunately, access to facilities for the provision of appropriate training in laparoscopy seems to be relatively limited and appears to

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have fallen significantly behind fast-moving procedural and technical developments in this surgical field.

Traditional surgical teaching and training within the framework of the master–apprenticeship model conducted in the operating theatre works well if there is a good case mix and unlimited time for juniors to participate and train. The introduction of current restrictions in resident working hours has severely impacted on the effectiveness of this traditional system.[1,2] Today, a surgical trainee needs to acquire a fit-for-practise set of skills in significantly less time than ever before. In addition, the focus on the acquisition of such skills has shifted to outside the operating theatre because of concerns regarding the ethics of learning basic laparoscopic skills on patients, patient safety and cost-effectiveness.[2–4]

MAS is unique in that it requires a different set of skills not routinely used in open surgery. Didactic sessions, simulator practice and wet-labs are established training approaches towards laparoscopy. However, simulator training in laparoscopy seems advantageous in that it facilitates the acquisition of unique skills not only by trainees but also by the experienced surgeon. Additionally, it allows one to learn at their leisure in a stress-free, structured and logical fashion.[1,5] Exclusively with simulation even the inexperienced learner can be trained to a predetermined skill level, with both basic and advanced techniques in MAS, before embarking on active practice in the operating theatre; for the new surgeon, the patient-based experience now becomes one of a refinement of existing surgical skills rather than an inexperienced learning curve.[3]

The aims of this study were firstly, to evaluate access to laparoscopic training facilities in the UK and, secondly, to establish the usefulness of a novel and integrated laparoscopic simulator (i-Sim™) compared to a conventional mannequin/box trainer with stack system.

2. Material and methods

To survey current access to laparoscopic training in the UK, questionnaires were sent to 133 consultants and trainees in urology, general surgery and gynaecology. The questionnaires (Appendix 1) were designed to assess the respondents' level of participation in laparoscopy, any training they had received and the facilities they currently used in order to develop their laparoscopic skills. Participants were also asked to volunteer information regarding their awareness of any currently available laparoscopic simulators and how useful they thought these simulators would be for their own training.

i-Sim™ (invented and developed by the company iSurgicals) is the first integrated laparoscopic simulator in the UK (Fig. 1). It approximates the size and weight of a large laptop computer. To assess its usefulness, i-Sim™ was compared to a conventional mannequin/box trainer with stack system by a group ($n = 51$) of trainee and consultant participants. The mannequin/box trainer with stack system employed contained two instrument ports and one port for the laparoscope. In comparison, i-Sim™ consists of a built-in single chip high-resolution camera that is mounted on an angled bracket and can be tilted at various angles. As the simulation is conducted, a real-time image may be viewed on a flexible high-definition screen. An innovative flexible bracket with multiple ports creates an open workspace that allows the simulated tasks to be easily changed (Fig. 1). i-Sim™ also provides options for recording, projection and wireless transmission of performed tasks.

Fig. 1 – Photograph of the integrated laparoscopic simulator (i-Sim™). This consists of a built-in single chip, high-resolution camera that is mounted on an angled bracket that allows it to be tilted at various angles. The innovative flexible bracket with multiple ports creates an open workspace that allows easy inter-changeability of a variety of simulated tasks that are to be conducted; these may be viewed on a flexible high-definition screen in real time.

Participants performed laparoscopic tasks on both simulators. These ranged from basic peg-transfer tasks to clipping and cutting to intra-corporeal knot tying. Based on their previous baseline laparoscopic experience, individual participants chose the complexity of their task and this was then sequentially conducted on both the simulators. On the basis of completion of the task on each simulator, individual participants were then requested *via* a questionnaire (Appendix 2) to assess both models based on particular features i.e., portability, image quality, set-up time and user-friendliness. A scoring system from 1 to 10 was applied with 1 being classed as poor and 10 being excellent. A nonparametric (Mann–Whitney) test, designed not to make assumptions about the distribution of the data, was employed to test for differences in scores given to both simulators. All p-values given are two-tailed. The questionnaire survey also assessed responses regarding the potential benefit of i-Sim™ to improve laparoscopic training in an efficient and cost-effective manner (Appendix 2).

3. Results

3.1. *Survey of access to laparoscopic training*

Survey questionnaires (Appendix 1) were sent to a participant group ($n = 133$) in specialities including general surgery,

urology or gynaecology and based on 36 different UK institutions; this group consisted of consultants and trainees (including registrars, staff grades, associate specialists and senior house officers). There were 100 respondents (with $n = 35$ consultants) and 86 were currently involved to some degree in laparoscopy; the remaining 14 respondents were excluded from the analyses. Of those with laparoscopic experience ($n = 86$), 37 (43%) had attended a laparoscopic course while only 13 (15%) had regular access to a skills lab and/or laparoscopic simulator. Fig. 2 shows the range of different training facilities for the respondents in this study identified as being employed to further their laparoscopic skills at their respective institutions.

Thirty-one of the 86 participants with laparoscopic experience (36%) believed they had opportunities towards training only during operations while 15 (17%) felt they had no access to training facilities for laparoscopy. Although only 23 respondents were aware of any particular type of laparoscopic simulators, 80 (93%) thought a laparoscopic simulator would be useful for training. This is re-enforced by the high percentage (70%) who indicated that it would be desirable to have one to two training sessions on a simulator per week; approximately 1 in 10 indicated that they would consider daily practice whereas a similar proportion thought that monthly access was adequate (Fig. 3).

3.2. *i-Sim™ versus mannequin/box trainer with stack system*

Fig. 4 shows the frequency distributions of scores given to a range of features by a different group of participants ($n = 51$); a right-hand shift in distribution away from zero

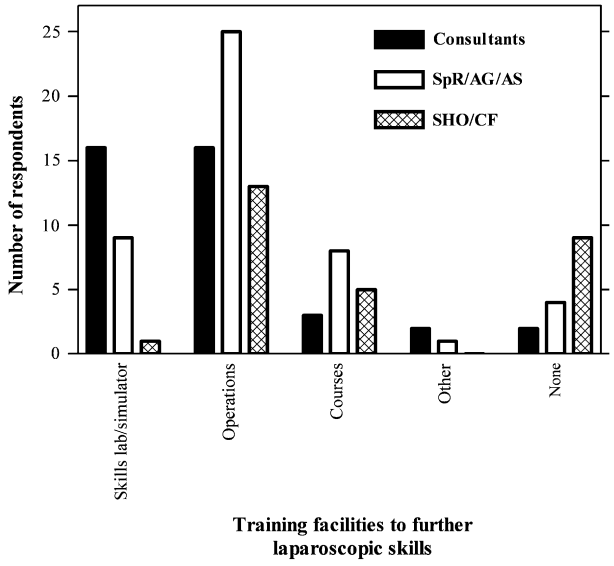

Fig. 2 – The range of different training facilities for the respondents ($n = 86$) in this study identified as being employed to further their laparoscopic skills at their respective institutions. Abbreviations: AG, associate (staff) grade; AS, associate specialist; CF, clinical fellow (registrar grade); SHO, senior house officer; and SpR, specialist registrar.

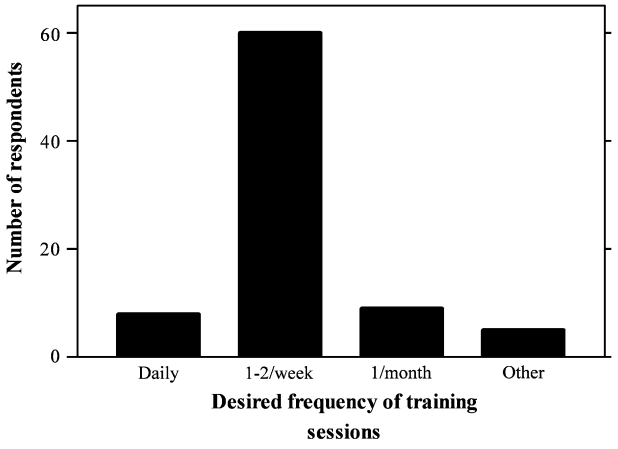

Fig. 3 – Desired frequency of training on a laparoscopic simulator among respondents ($n = 86$) who had laparoscopic experience.

indicates an increase in satisfaction. For each feature (set-up, image quality, user-friendliness, ease to change tasks, portability, different locations, storage) i-Sim™ scored a significantly higher ($p < 0.0001$) satisfaction rating than the conventional mannequin/box trainer with stack system. There was universal agreement from all the participants that regular practice on such simulators would improve the laparoscopic skills of surgeons, trainees and nursing staff. Of this group, 42 (82%) believed that regular practice on such simulators would reduce the learning curve for laparoscopy. At the same time, 50 (98%) reported that the simulator-assisted improvement in a trainee's laparoscopic skills would allow more efficient patient-based learning within the operating theatre. It was also felt that access to simulator training would reduce operating time and complications, and as a consequence increase cost-effectiveness.

4. Discussion

The advent and evolution of MAS has led to traditional open surgical procedures becoming increasingly replaced with minimally invasive alternatives that generally require a longer learning curve in order to acquire a new set of specific skills.[5,6] It has been shown that the basic laparoscopic cognitive and psychomotor skills can be learnt with simulators outside the operating theatre. Such simulator-based training will probably never fully replace the traditional patient-based apprenticeship learning and mentoring in operating theatres. However, because a trainee may need as many as 100 cases to fully develop their basic laparoscopic skill in the operating theatre, simulators might offer a more efficient and safe method of training in MAS. Trainees can progress partway along the learning curve prior to performing an operation on a patient while practising surgeons can improve or develop new skills.[7–9]

Our survey of access to laparoscopic surgery training suggests that the majority of learning is still operating

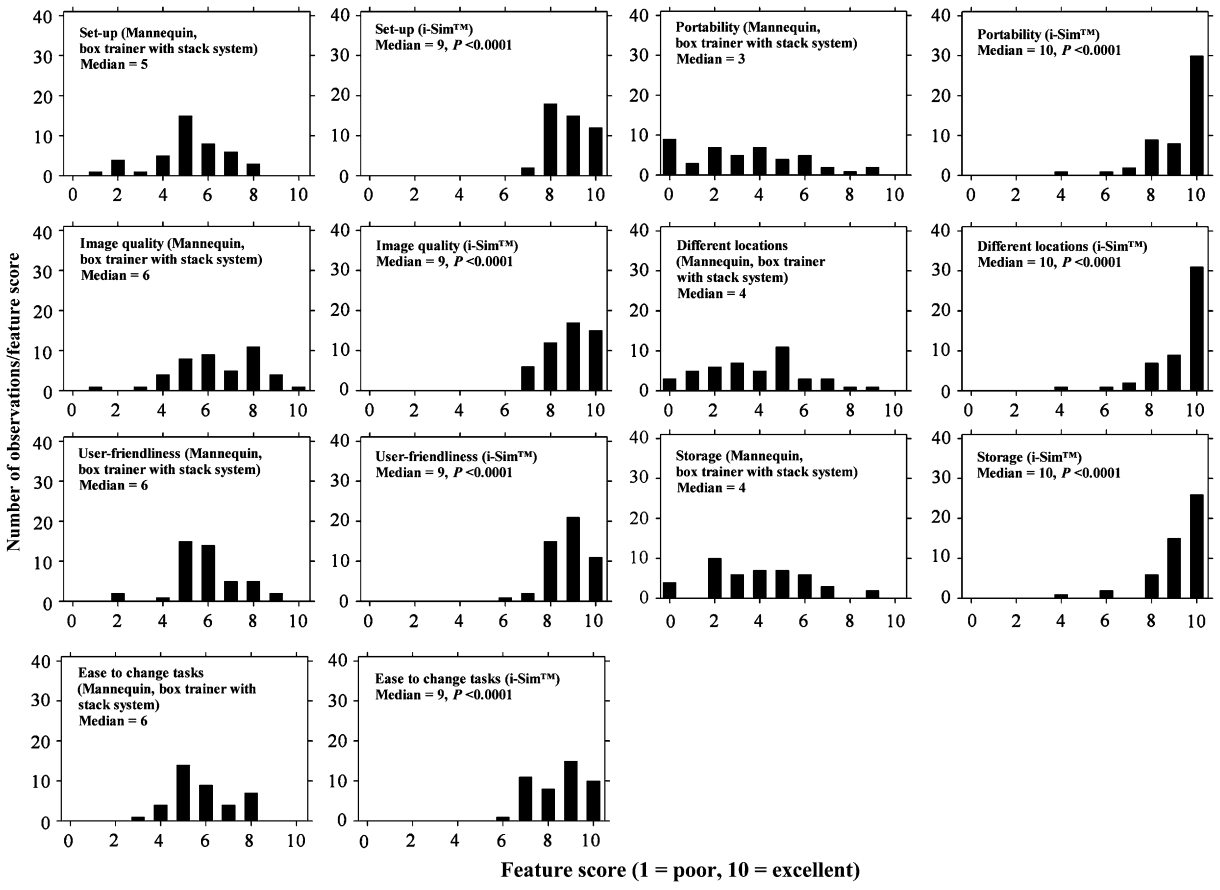

Fig. 4 – Frequency distributions of scores given to a range of features (set-up, image quality, user-friendliness, ease to change tasks, portability, different locations, storage) by a group of participants ($n = 51$); a right-hand shift in distribution away from zero indicates an increase in satisfaction. A nonparametric (Mann–Whitney) test was employed to compare the distributions of individual feature scores given to i-Sim™ compared to a conventional mannequin/box trainer with stack system. All *P*-values given are two-tailed; the distributions of individual feature scores on each simulator were compared.

theatre-based and there is a paucity of regular training facilities for MAS in the UK. There was an exceptionally strong agreement that regular training on laparoscopic simulators would be useful. Some 70% expressed a desire to practise on a laparoscopic simulator at least one to two times per week (Fig. 3), although only 41% had such access (data not shown). Two similar surveys of general surgery and urology programmes in the US showed that 55% and 76% of the programme directors surveyed, respectively, had skills labs at their disposal and the majority considered such a facility a core element of training.[10,11]

There are various types of simulators that can broadly be classified as physical, virtual reality (VR) or hybrid. Though there is evidence that all simulators are effective in teaching basic laparoscopic skills, there appears to be no clear benefit of VR simulators over physical models. VR simulators also lack haptic feedback. As technology becomes increasingly sophisticated, simulators may become an integral component of the surgical curriculum.[9,12]

i-Sim™ was perceived to have several advantages over the traditional box simulator (Fig. 4). Setting up i-Sim™ is akin to opening a laptop and pressing the ''on'' key. Additionally, it does not require a light source other than ambient room light. The recording facility can be used to monitor the progress by both trainer and trainee, and the projection facility may be used for teaching. In our survey, portability and ergonomic design were perceived to be significant features favouring regular use of i-Sim™ at various locations (Fig. 4).

Although the potential implications of these surveys are important, this study has some limitations. The small sample size surveyed might be a limiting factor and the opinions reported by respondents may not accurately reflect the views of all surgical trainers or trainees. In addition, i-Sim™ is a prototype; further studies are now in progress towards a validation exercise.

5. Conclusion

This study has addressed the ever increasing need for structured and simulation-based training facilities for MAS. It also proposes a new, innovative simulator design that could possibly become a readily accessible, cost-effective alternative to current training approaches to laparoscopy.

Conflicts of interest
S.S. Matanhelia is advisor to iSurgicals in which his family has financial interests. None of the other co-authors have any conflicts of interest to declare.

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None, this research was conducted in our own time.

Ethical approval
None required.

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Appendix 1.

Survey of access to laparoscopic surgery training

Please check the relevant boxes

1) What is your position?

☐ Consultant ☐ Associate specialist ☐ Staff grade ☐ SpR/resident

☐ SHO/FY1/FY2 ☐ Scrub nurse ☐ Other (please state) _____

2) How would you describe your current involvement in laparoscopic surgery?

☐ Trainer ☐ Trainee ☐ Scrub nurse ☐ Not involved in laparoscopy

****If you are not involved in laparoscopy, please stop here and return the form****

3) What training have you already undertaken for laparoscopic surgery?

☐ Dry lab course ☐ Wet lab course ☐ Mentoring ☐ None ☐ Other _____

4) What facilities do you currently use to develop your skills in laparoscopic surgery?

☐ Skills lab ☐ Laparotrainer in theatre/department ☐ During operation

☐ None ☐ Other (please state) _____

5) How often do you have access to these facilities for laparoscopic surgical training?

☐ Anytime ☐ Once/ twice a week ☐ Once a month

☐ No access ☐ Other (please state) _____

6) Are you aware of currently available laparotrainers? ☐ Yes ☐ No

If yes then please give details here: _____

7) Would you find a laparotrainer useful in your training? ☐ Yes ☐ No

8) Where would you like a laparotrainer to be available? (Please select one or more options)

☐ Post-graduate centre ☐ Operating theatre ☐ Surgeons' room

☐ Office ☐ Home ☐ Other (please state) _____

9) How often would you like to practice on a laparotrainer?

☐ Daily ☐ Once/ twice a week ☐ Once a month ☐ Other (please state) _____

10) How much do you think your department/institution would be willing to pay for a laparotrainer?

☐ £1500 ☐ £2000 ☐ £3000 ☐ £5000 ☐ Other (please state) £_____

11) Please give details of your place of work:

Name of hospital/institution _____
City _____
Country _____

Thanks for your time. To return the form, save document on your desktop and attached the saved file to your reply e-mail.

Appendix 2.

Laparaoscopy simulators survey

	Please give a score from 1 to 10 (1 being poor and 10 being excellent)	Box trainer	i-Sim™
1	How easy is it to set up the simulator?		
2	How good is the quality of the image on the screen?		
3	How user-friendly is the system for training laparoscopic skills?		
4	How easy is it to change tasks during training?		
5	How portable is the simulator?		
6	How easy is it to place the simulator in different locations e.g., office, skills lab, and theatre?		
7	How easy is it to store the simulator?		

	Please answer agree or disagree	Agree	Disagree
1	Regular practice on such simulators will improve the skills of surgeons, trainees and nursing staff		
2	Regular practice on such simulators will accelerate the learning curve		
3	Improvement in a trainee's laparoscopic skills will offer more opportunities for trainees to learn during operations		
4	Improvement in laparoscopic skills due to regular practice will reduce the operating time		
5	Improvement in laparoscopic skills due to regular practice will reduce complications and conversion rates		
6	Reduced operating time and complications will lead to improved patient care, shorter hospital stay and early return to work		
7	The above measures will save money for the hospital and NHS (2 hours theatre time = 3 days hospital stay = approximately £1100)		

Please make any additional comments on the reverse side

Name _____ Department _____

Position ☐ Consultant ☐ Associate specialist/ staff grade ☐ SpR/ST1/ST2

☐ SHO/HO/F1/F2 ☐ Nursing staff ☐ Other _____

Hospital _____ City _____

Thank you for taking the time to participate in our survey

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